RESEARCH DEPARTMENT

C.W. interference with monochrome u.h.f. television reception

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SUMMARY

The protection ratios for a monochrome television transmission against an interfering c.w. signal, as given in CCIR Recommendation 418, 1963, in the case of Standard I (the current U.K. standard on u.h.f.), were confined to frequency offsets between -2 Mc/s and +5 Mc/s from the vision carrier frequency. The work described in this report extends this data to offsets of up to 6·5 Mc/s, including the sound carrier frequency. Curves are shown of the levels of a c.w. signal giving impairments graded 1½ and 3½; the relative incidence of visible and audible impairments and the effects of receiver tuning are discussed.*

1. INTRODUCTION

Television picture and sound signals may each be impaired if c.w. interference is present during reception. Such interference can be caused, particularly in the u.h.f. band, by the radiation of signals from the local oscillators of other receivers, either at the fundamental frequencies of those oscillators or at their harmonics. The permissible levels for such radiation at u.h.f. from these sources are under consideration in the U.K. and, in this work, it is necessary to know the protection ratios required, for a given degree of impairment, against a c.w. signal at any frequency within the passband of a u.h.f. television receiver correctly tuned to a transmitter using the relevant U.K. standard (CCIR Standard I).

Information published initially in the I.T.U. Technical Data[1], and later embodied in CCIR Recommendation 418[2], shows the c.w. signal levels giving interference acceptable for between 1% and 10% of the time as a function of frequency offset in the range −2 Mc/s to +5 Mc/s relative to the vision carrier frequency. Further work was therefore required in order to assess the impairment caused at offsets greater than 5 Mc/s so as to include interference with the sound signal and any other effects in the vicinity of the sound carrier frequency, which is 6 Mc/s higher than the vision carrier frequency.

2. TEST CONDITIONS

A 625-line monochrome television picture and f.m. sound signal (Standard I) were generated at v.h.f. and combined with a variable-frequency c.w. signal before conversion to u.h.f. The u.h.f. signal was fed in turn to each of five** currently-available commercial dual-standard television receivers. Each receiver was adjusted to give a reproduction of Test Card "C" of satisfactory brightness and contrast and was tuned to give the best compromise between high definition and freedom from sound-on-vision effects. Other tuning conditions were also investigated as discussed in Section 4.4. The c.w. frequency offset could be maintained to within ± 3 kc/s and was adjusted critically before each observation to give the most visible or most audible impairment. In most cases, the most visible interference pattern was one which had a structure of nearly vertical stripes and the most audible interference was one which gave a noticeable whistle during pauses in the sound modulation. The level of the c.w. signal was adjusted at each offset until a particular grade of impairment was observed, whether it occured on the picture (Test Card "C") or on the sound (speech), as judged by two engineers at a distance of six times the picture height.

3. ASSESSMENT OF PICTURE AND SOUND IMPAIRMENT

A scale of impairment has been established[4,5] with six points or grades of impairment as given below:

1. Imperceptible
2. Just perceptible
3. Definitely perceptible but not disturbing
4. Somewhat objectionable
5. Definitely objectionable
6. Unusable

* See Section 3.

** Observations were also made on a sixth receiver. It was comparable in performance with the others but, owing to a progressive fault, the quality of picture and sound deteriorated so that the full range of tests could not be completed on this receiver. For this reason none of the results for the sixth receiver were included in Figs. 1 and 2.

This scale may be used to describe either long-term average impairment of a service caused by interference which has different levels at different times or the particular impairment caused by a constant level and type of interference which is continuously present. The observations were confined to the latter case but, even then, the impairment must be considered as the average for all viewers/listeners and all pictures/sounds unless otherwise stated. With this in mind, it is convenient to describe an impairment at the threshold of perception as grade 1½ and one at the threshold of objection as grade 3½. These two grades of impairment can be assessed reasonably accurately by a single practised engineer viewing a receiver showing Test Card "C".

4. RESULTS

4.1. Treatment of Observations

The test procedure described in Section 2 resulted in ten observations of the c.w. interference level for each frequency offset and for the two grades of impairment mentioned above. These were plotted as shown in Figs. 1 and 2 where the circles indicate that the picture was impaired and the crosses indicate that the sound was impaired. In order to show the spread of results, the solid lines were drawn to enclose most of the observed levels, ignoring the best and the worst points at each offset, so as to allow for a small number of false observations. The broken lines represent the protection ratios suggested for the two grades considered.

Figs. 1 and 2 cover offsets extending from −500 kc/s to +300 kc/s from the sound carrier frequency as this was initially considered to be the most important region. As can be seen, however, the spread of results is increasing as the offset increases from −400 kc/s to −500 kc/s. Further measurements were therefore made to investigate this trend at offsets extending to −1500 kc/s (+4·5 Mc/s from the vision carrier). Two of the receivers were found to require protection ratios of over 30 dB for grade 1½ and over 20 dB for grade 3½ at +5 Mc/s from the vision carrier frequency. Of these two receivers, one showed roughly equal impairments of sound (mush) and picture (sound-on-vision) over the range +4·5 Mc/s to +5·5 Mc/s. Although these impairments could be reduced by a slight retuning of the receivers, they were taken into consideration in constructing the complete curves of protection ratios discussed in Section 4.2.

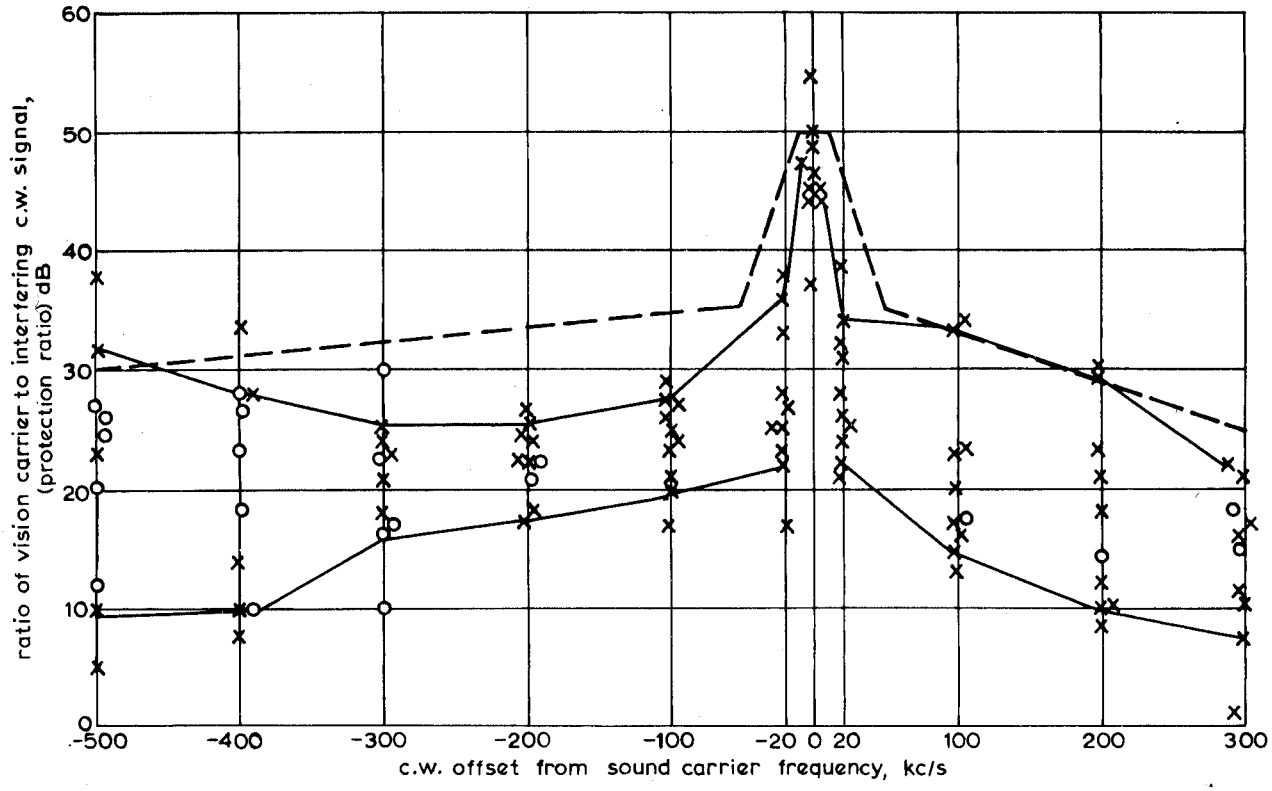

Fig. 1 - Protection ratios : best compromise tuning : grade 1½

o impairment of picture

x impairment of sound

Having established the ratios in this way, the effects were demonstrated to a larger group of engineers who were in broad agreement with the results so obtained.

4.2. Comparison with CCIR Curve and Proposed Extension

The interference level given by the CCIR curve[2] at an offset from the vision carrier frequency of +0·5 Mc/s was assessed as grade 3½ under the conditions described in Section 2. This curve has been reproduced in Fig. 3 for offsets up to about 4·5 Mc/s where it joins a new curve continuing to offsets of +6·5 Mc/s based on the results just given for the same grade of impairment. The aim was to produce simple, idealized curves which would be adequate for most receivers, allowing for the effects of some degree of mistuning, as discussed in Section 4.4. This idealization has inevitably obscured some of the finer structure of the protection ratio variation. In particular, the detailed shape of the peak at the sound carrier frequency would show two distinct peaks at approximately ±5 kc/s about the sound carrier itself and less well-defined pairs of peaks about offsets which are multiples of the line repetition frequency.

In order to reduce the impairment at +0·5 Mc/s offset above the vision carrier frequency from grade 3½ to grade 1½, the c.w. interference had to be reduced by 15 dB and, although no detailed measurements were made, this reduction appeared to be maintained at offsets of up to +5 Mc/s. At offsets of from +5 Mc/s to 6·5 Mc/s, however, the difference in c.w. levels between the two grades decreased to about 5 dB.

4.3. Variation of the Character of the Impairment

If the frequency of the interfering signal is close to the vision carrier frequency, the principal impairment is to the picture and this is still true at offsets of up to about 4·5 Mc/s when the interference pattern has a very fine structure. At offsets between 4·5 Mc/s and 5·5 Mc/s, there is a tendency for a coarser pattern to become more visible and for sound modulation to be present on the picture. At offsets of between 5·5 Mc/s and 6·5 Mc/s the principal impairment is mainly that caused to the sound signal in the form of either discrete whistles or increased background (mush) similar to picture modulation of the sound signal. Within ± 20 kc/s of the sound carrier frequency at +6 Mc/s offset, the impairment is predominantly to the sound signal and consists of a whistle during pauses in the wanted modulation and distortion of the modulation, as experienced in co-channel interference with f.m. broadcast reception.

4.4. Influence of Receiver Tuning

All the foregoing remarks and the results given in Fig. 3 refer to the average behaviour of the five receivers when tuned for the best compromise between high definition and freedom from sound-on-vision effects in the absence of c.w. interference.

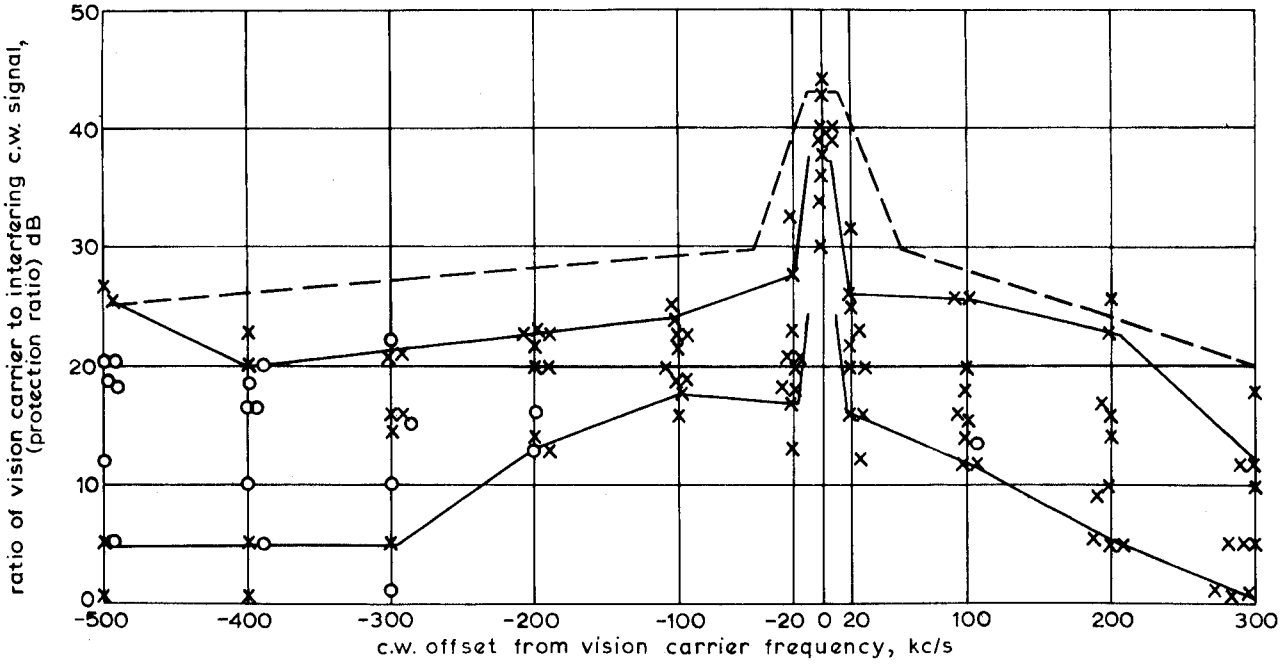

Fig. 2 - Protection ratios : best compromise tuning : grade 3½

O impairment of picture

X impairment of sound

Most receivers can, however, be tuned to a lower frequency (away from the sound carrier) by one or two megacycles per second* while retaining an acceptable quality of picture and sound. In this latter tuning condition, the protection ratios required at offsets of within ± 20 kc/s of the sound carrier were increased by about 2 dB but, at other offsets in the range 4·5 Mc/s to 6·5 Mc/s, the incidence of impairments to the picture was greatly diminished.

Likewise, most receivers can be tuned towards the sound carrier giving a higher definition with some acceptable degree of patterning. In this case, the presence of c.w. interference again slightly increased the required protection ratios for the sound signal at offsets of within ±20 kc/s, and increased them by about 6 dB at other offsets above 4·5 Mc/s as a result of greater picture impairment.

5. DISCUSSION OF RESULTS

Although the measurements at +0·5 Mc/s offset, together with some observations at higher offsets, confirm that the CCIR curve[2] is for the most part appropriate for grade 3½ impairment, a slight modification to this curve is necessary above about 4·5 Mc/s as shown in Fig. 3, where interference between the c.w. signal and the f.m. sound carrier begins to predominate. The 15 dB increase in protection ratio required for grade 1½ impairment at +0·5 Mc/s offset is consistent with the text of CCIR Recommendation 418[2] which indicated an increase in the range 10 to 20 dB for "just perceptible" interference.

C.W. interference at offsets of from 4·5 Mc/s to 6·5 Mc/s gives rise to impairment involving a more complex mechanism which varies from receiver to receiver and depends to some extent on receiver tuning. The protection ratio given by the narrow peak in the curve of Fig. 3 at +6 Mc/s (43 dB for grade 3½) may be compared with the protection ratio required between f.m. broadcast services. Using CCIR Recommendation 412[3], the ratio for acceptable interference is 31·5 dB for two sound programmes with a peak deviation of 50 kc/s. Making a 7 dB allowance for the sound/vision carrier ratio, this would give a protection ratio of 38·5 dB for a tele-

* Such excessive mistuning, however, may give rise to interference in a neighbouring receiver tuned to another television channel.

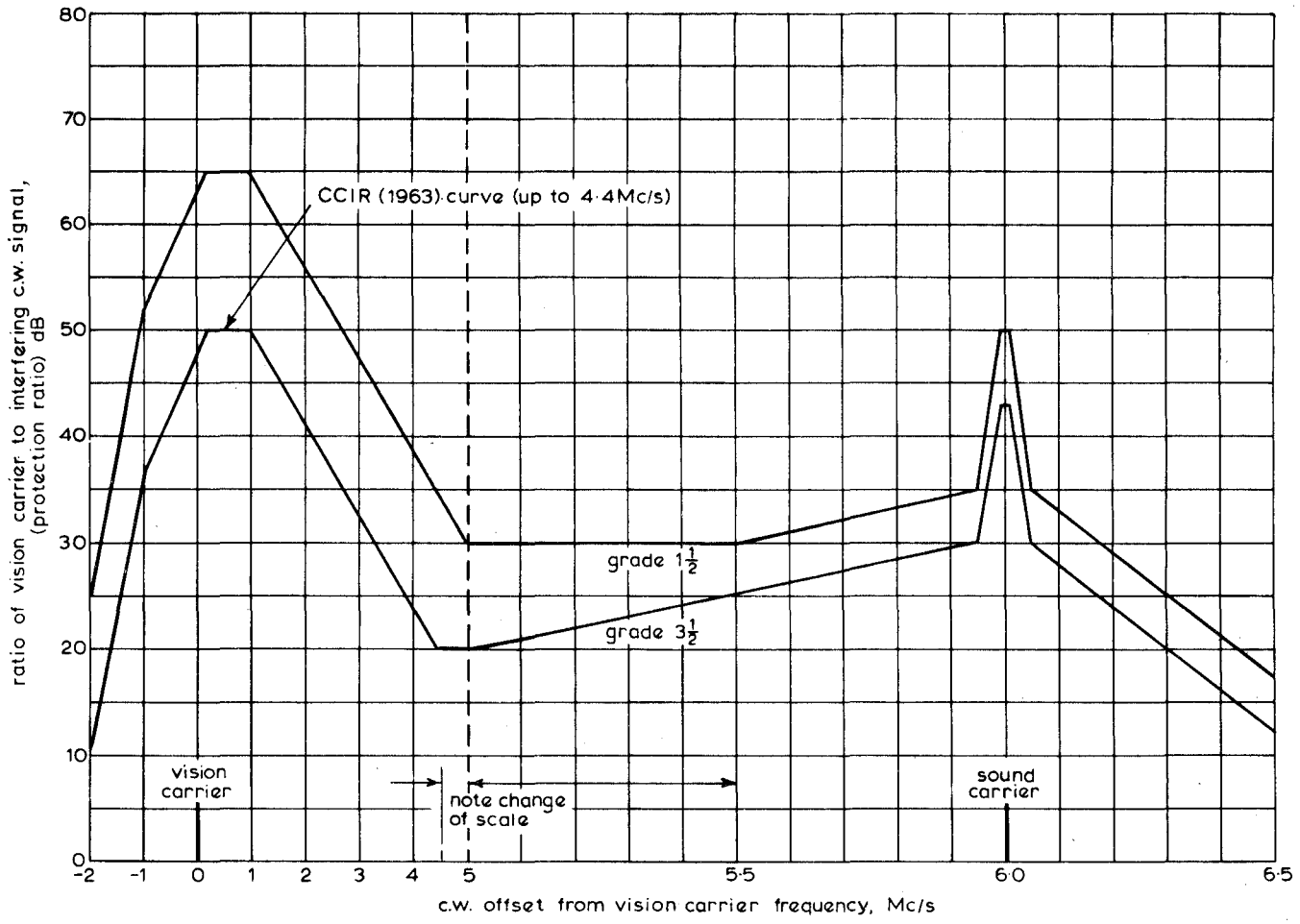

Fig. 3 - Protection ratios for grades 1½ and 3½ c.w. interference in monochrome u.h.f. television reception

vision transmission (for which the peak vision power acts as the reference level) against an interfering f.m. sound transmission. The independent result of 43 dB shown in Fig. 3 is some 4 dB higher as would be expected for a c.w. interfering signal adjusted for the most audible beat effect rather than a f.m. signal

It has been assumed in this work that the c.w. interference is not closely controlled in frequency and for this reason the finer variations of the protection ratios have been ignored. If, however, the interference arises from other co-channel television, f.m. or c.w. signals using offsets with suitably controlled frequencies, the protection ratios would be considerably lower than those given here not only within the vision transmission band, as is well known, but also in the region of the sound carrier frequency. This situation is therefore covered separately in Recommendation 418; in particular f.m. sound transmissions near the wanted sound carrier are dealt with in Section 6 of the Recommendation.

6. CONCLUSIONS

Curves of protection ratios required against an interfering c.w. signal by 625-line monochrome television transmissions using Standard I have been proposed as a slightly modified and extended version of the CCIR 1963 curves, as shown in Fig. 3 for an offset between −2 Mc/s and +6·5 Mc/s from the vision carrier frequency. They have been based on new observations made on five commercial u.h.f. television receivers for offsets from +4·5 to +6·5 Mc/s so as to include interference with the sound channel itself and interactions with the sound signal which impair the picture. Departures from the normal receiver tuning conditions do not greatly affect the sound impairment but have a marked effect on the impairment of the picture by the interference.

The work described concerns monochrome transmission and reception. The protection ratios in the case of colour transmissions, with monochrome or colour reception, will require further study.

7. REFERENCES

1. I.T.U. Technical Data (Stockholm 1961), p. 37, Section 3.2 and Fig. 24, curve e_2.

2. CCIR, Vol. 5, Sound Broadcasting, Television (Geneva 1963), Recommendation 418, p. 59, Section 1 and p. 64, Section 4, Fig. 5, curve e_2.

3. Ibid. Recommendation 412, p. 41 and p. 43, Fig. 2.

4. SPROSON, W.N., WATSON, S.N., CAMPBELL, M.: "The BBC Colour Television Tests : An Appraisal of Results", BBC Engineering Division Monograph No. 18, May 1958, p. 14, Table 2, Scale 1.

5. Report of the EBU Ad Hoc Group On Colour Television, 2nd Edition, February 1965, p. 6, Section 1.4.

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